DOCUMENT RESUME

ED 134 934 CS 003 188

AUTHOR Armbruster, Bonnie B.
TITLE Learning Principles from Prose: A Cognitive Approach Based on Schema Theory. Technical Report No. 11.
INSTITUTION Illinois Univ., Urbana. Center for the Study of Reading.
SPONS AGENCY National Inst. of Education (DHEW), Washington, D.C.
PUB DATE Jul 76
GRANT NIE-G-74-0007
NOTE 48p.

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS *Advance Organizers; *Concept Formation; Conceptual Schemes; Learning; *Learning Theories; *Reading Processes; *Reading Research
IDENTIFIERS *Center for the Study of Reading (Illinois); *Schemata

ABSTRACT

This report provides an overview of concept and principle-learning studies and traces the theoretical basis for schema theory, which asserts that all knowledge is assimilated into a general cognitive framework. The procedures of an original study are described, which was designed to test the hypothesis that the inclusion of a "domain statement" in the explanation of a principle--that is, a statement of the range of applicability of the principle--would produce a higher level of understanding than would the presentation of a principle or example alone or the presentation of a principle in conjunction with an example. Although data, collected from 395 juniors and seniors from a middle-class and upper-middle-class public high school in suburban Chicago, did not confirm the major hypothesis, the findings of previous studies, which indicated that subjects perform better on test items that are similar and that a pretest facilitates posttest performance, were supported. Tables illustrating the text are included. (KS)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED134934

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

Technical Report No. 11

LEARNING PRINCIPLES FROM PROSE: A COGNITIVE APPROACH BASED ON SCHEMA THEORY

Bonnie B. Armbruster

July 1976

University of Illinois at Urbana-Champaign
Laboratory for Cognitive Studies in Education
236 Education Building
Urbana, Illinois 61801

CS 003 188

The research reported herein was supported in part by the National Institute of Education under Contract HEW-NIE-G-74-0007.

ABSTRACT

Studies on learning concepts and principles from examples and/or definitions have failed to yield consistent results to guide educators. However, a recently resurrected theory of memory, schema theory, can help explain contradictory results as well as suggest a useful research methodology and an instructional aid for the teaching of concepts and principles. The present study investigated the hypothesis suggested by schema theory that a "domain statement" of a principle (a statement of the range of applicability of the principle) would produce superior learning to presentation of a principle or example alone or a principle in conjunction with an example. Although the major hypothesis was not confirmed, the study replicated earlier results that subjects perform better on test items that are similar rather than dissimilar to the presented example and that a pretest facilitates posttest performance. In addition, the study utilized a methodology, principle analysis, that could be a useful tool for both researchers and educators.

INTRODUCTION

Most learning in school is a matter of mastering the basic ingredients of intellectual functioning -- the concepts and principles interrelating these concepts. A "concept" is here defined as a class of objects or events, all of whose members share certain features or attributes. A principle consists of two or more concepts related in some way (Gagne, 1965; Anderson & Faust, 1973) such that they form generalizations or laws that apply to a universe of instances (Roderick, 1969). Despite the obvious importance of concept and principle learning, educational and psychological research to date provides woefully little guidance to the practical educator. The results of laboratory studies have little applicability to classroom learning, and the results of more realistically school-oriented concept learning studies are inconsistent and confusing. Fortunately, a recently resurrected theory in cognitive psychology, schema theory, offers a potentially fruitful perspective for both researchers and educators concerned with the learning of concepts and principles. From the perspective of schema theory it is possible to explain the inconsistent results of concept learing studies as well as to generate a useful methodology for future research. Furthermore, schema theory suggests a potentially valuable aid for the teaching of concepts and principles.

The study reported here was an attempt to use schema theory in developing an experimental methodology as well as to investigate an hypothesis suggested by schema theory concerning the teaching of principles. The study was designed to approximate the school learning situation

by focusing on the learning of principles from prose and using a measure of "transfer" or "application" as the dependent variable.

Only one published study was found that pertains to the learning of principles per se. However, there is a vast literature on concept learning. This literature would appear to be relevant to principle learning, since principles are relationships between concepts. Therefore, this paper will begin with a brief overview of concept learning studies pertaining to the characteristics of the instructional situation. An outline of schema theory will then be introduced, followed by the proposition that schema theory provides a framework from which to interpret the results of the concept learning studies as well as a suggestion for a potentially more fertile approach to concept learning for both researcher and educator. Schema theory will then be extended to principles, forming the basis of the rationale for the present study.

Overview of Concept and Principle Learning Studies

A comprehensive source of information on experimental results concerning the effect of characteristics of the instructional situation on concept learning is Clark's (1971) review of hundreds of concept learning studies. The review discloses an impressive list of significant findings; the detailed prescriptions that Clark derives from these findings would seem hearty fare for classroom teachers starved for "scientific" guidance in performing their concept teaching chores. Unfortunately, however, major differences between the type of concept learning in the traditional laboratory experiments reviewed by Clark and in the actual school situation cast serious doubt on the appropriateness of generalizing

such research findings to teaching in the classroom. Several critics (cf. Carroll, 1964; Clark, 1971) have listed the major discrepancies between the laboratory and school learning situations.

(1) The goal of the concept learning task is very different in the laboratory and classroom situations. In most laboratory learning situations, subjects are asked to classify or categorize already familiar stimulus dimensions until they have induced a concept such as "solid blue triangle." Battig and Bourne (1961) claim that such studies are not investigating concept formation but merely concept identification. In school, on the other hand, concept learning is likely to involve the formation of totally new, unfamiliar concepts.

(2) The concept task or the strategy involved in learning the concept is very different in the laboratory and classroom situations. Laboratory studies primarily entail the inductive or "discovery" learning of concepts from a presentation of positive and negative instances. School learning usually involves the deductive or expository method of teaching concepts whereby the individual identifies and describes the critical attributes of the concept from a formal definition.

(3) The instances and dimensions of concepts in the laboratory context are very different from the instances and dimensions of concepts in the classroom context. The concepts of laboratory studies involve concrete, physical, visually perceived objects having a finite number of dimensions with finite, discrete values. Classroom learning, however, involves abstract, verbally communicated concepts possibly having infinite dimensions with infinite, continuous values.

(4) The evaluation of concept learning is different in the laboratory and the classroom. In concept identification studies, the usual measure of concept learning is acquisition: the experimental subject performs a simple sorting task indicating whether or not the concept has been attained. With school learning, on the other hand, the more important measure is a measure of comprehension, transfer, or application.

In light of the sharp differences between laboratory and classroom learning, it is doubtful

> . . . whether there is any continuity, with respect to psychological "processes," between the inductive, nonverbal type of learning studied in the psychological laboratory under the guise of "concept learning" and the usually more deductive, verbal-explanatory type of teaching used in the classroom and in typical text materials. (Carroll, 1964, p. 180)

Therefore, the results that Clark found are not thought to be sufficiently relevant to a study of classroom concept learning to warrant further consideration here.

Not all concept learning studies, of course, have been confined to the laboratory. A raft of other concept and principle learning studies have been conducted under conditions more closely approximating the classroom learning situation. Here again, however, the practical educator meets defeat in his quest for scientific guidelines, for the results of this subset of concept and principle learning studies are contradictory and confusing. With regard to the most relevant issue -- the use of definitions and examples in teaching concepts and principles -- the conclusions range from one extreme to the other. At one end of the continuum is the assertion "It is apparent that the definition by itself was not a sufficient teaching technique to lead students to generalize and discriminate as completely as an instructor would want" (Markle & Tiemann, Note 2,

p. 5) while at the other end is the finding that " . . . people can easily learn concepts from definitions" (Anderson & Kulhavy, 1972, p. 389). A brief, nonexhaustive survey of studies ranging along the continuum follows.

Research on the Use of Examples Only

A study by Swanson (reported in Klausmeier, Ghatala, & Frayer, 1974) investigated the effect of number and type of concept instances on the acquisition of concepts in the absence of a definition. Sixth graders received written lessons on three interrelated environmental concepts in one of four treatment groups: (1) a "rational set" (Markle & Tiemann, Note 2) (the instances logically needed to permit both generalization to new instances and discrimination to noninstances) of both positive and negative instances, (2) a rational set of positive instances but no negative instances, (3) two positive instances and no negative instances, or (4) control -- three lessons unrelated to the test items. The four dependent variables measured were (1) correct classification of new instances, (2) overgeneralization, (3) knowledge of concept definitions, and (4) knowledge of interrelationships among concepts. The important result was that subjects in Treatment Condition 1 did better than subjects in the other three treatment conditions, a result also found in a replication by Feldman (reported in Klausmeier et al., 1974) using three mathematical concepts. Klausmeier et al. (1974) conclude, "The results of these two studies, taken together, suggest that a rational set of both positive and negative examples should be presented when teaching a concept" (p. 189).

Research on the Use of Both Examples and Definitions

A number of studies have either used a combination of definition and examples or compared the role of examples vs. definitions in the

learning of concepts. Another study by Swanson (reported in Klausmeier et al., 1974) employed the same three concepts as in the first study. In this study the four treatment conditions are (1) definition plus a rational set of positive and negative instances, (2) definition plus a rational set of positive instances only, (3) definition plus two positive instances, and (4) control -- three lessons unrelated to the test items. The posttest measured three variables of ability to correctly identify new instances, knowledge of concept definitions, and knowledge of interrelationships among the concepts. Results showed no significant differences among the three treatment groups on correct classification of new instances. A replication by Feldman (reported in Klausmeier et al., 1974) showed the same pattern of no differences on all three dependent variables. The conclusion of Klausmeier et al. (1974) on the basis of this study is

> . . . the number and type of instances presented are less important when a concept definition is provided than when instances alone are used to teach a concept. If a concept definition is given, the number and type of instances do not have a significant effect on the classificatory level of concept attainment. (p. 202)

Markle and Tiemann (Note 2) conducted a study concerning the concept morpheme in which experimental subjects (college students) received either a carefully constructed definition of critical attributes with or without a minimum rational set of examples, the definition of critical attributes and a technical statement of noncritical attributes with or without examples, or the definition of critical attributes and a nontechnical statement of noncritical attributes with or without examples. The two dependent variables were correct classification of new examples (generalization) and nonexamples (discrimination). The results showed no significant

differences among the groups on the basis of type of definition, but the provision of examples significantly improved generalization. A second study comparing a group receiving a dictionary definition (including examples) with a group receiving the dictionary definition plus a rational set of examples also indicated that the addition of a full range of examples improved generalization over a dictionary definition only. Markle and Tiemann (Note 2) conclude that

> . . . providing a full range of examples proved a more powerful variable controlling generalization than providing verbal descriptions of the full range of examples, that is, the statement of irrelevant attributes included in the definitions. (p. 11)

Other studies employ combinations of examples and definitions in teaching concepts. In another study by Swanson (reported in Klausmeier et al., 1974) concerning the three environmental concepts, sixth graders were in one of four treatment conditions: (1) rational set of both examples and nonexamples, (2) rational set of both examples and nonexamples plus a definition, (3) rational set of both examples and nonexamples plus a definition plus prompting (question designed to direct the student's attention to the critical attributes), and (4) control -- three lessons unrelated to the test items. The dependent variables were identification of new instances, knowledge of concept definitions, and knowledge of interrelationships among the concepts. The results showed Condition 1 to be superior to Condition 2 and Condition 2 to be superior to Condition 3. Surprisingly, Condition 1 subjects performed significantly better than Condition 2 subjects; in this case, therefore, presentation of a definition actually suppressed concept acquisition. However, a replication by

Feldman (reported in Klausmeier et al., 1974) showed the opposite effect: in this case, definition plus instances was superior to instances alone. Klausmeier et al. (1974) conclude

> (a) Concept definitions alone may lead to a significant amount of learning. (b) When a rational set of examples and nonexamples is presented, the addition of a concept definition may or may not facilitate concept mastery. (p. 207)

Merrill and Tennyson (1971) conducted a study in which college students were taught the concept of trochaic meter in one of eight treatment conditions: (1) definition -- identification of the relevant attributes shared by a set of objects in a given class, (2) attribute definition -- definition and clarification of each attribute of a concept class, (3) exemplar-nonexemplar -- display of instances and noninstances of a concept class, (4) attribute prompting -- explanatory information indicating class membership and identifying relevant attributes for each exemplar and absence of relevant attributes for each nonexemplar, (5) definition plus attribute definition plus exemplar-nonexemplar, (6) exemplar-nonexemplar plus attribute prompting, (7) definition plus exemplar-nonexemplar plus attribute prompting, (8) definition plus attribute definition plus exemplar-nonexemplar plus attribute prompting. The four dependent variables were the differences between predicted error scores and mean error scores for correct classification of new instances, overgeneralization, undergeneralization, and misconception. For the correct classification dependent variable, the definition plus exemplar-nonexemplar treatment groups performed significantly better than treatment groups provided with only definitions or with only exemplars-nonexemplars. The most effective treatment overall was the definition plus attribute definition plus exemplar-nonexemplar plus attribute prompting.

In a study by Johnson and Stratton (1966), college students learned four concepts in one of five ways. One group was trained to define the concepts in their own words after seeing nonsynonym definitions. A second group was expected to match new synonyms to the concepts after learning the concepts from four synonyms each. A third group was trained to classify descriptions of objects and events as instances or noninstances of the concepts. A fourth groups used the concepts in sentences after learning the concepts from the context provided by a short story. A fifth "mixed program" group received for each concept a paragraph containing a definition, a context sentence, two synonyms, and an example. The dependent variables were total and subtotal scores on an achievement test measuring ability to (1) define each concept, (2) classify new instances of each concept, (3) select new synonyms for each concept, and (4) use each concept in a sentence. Results showed no evidence of a relationship between training method and performance on the subtest corresponding to that method; all single treatment methods performed equally well on all subtests. In other words, for the purposes of this review, learning from a definition was just as effective as learning from examples. However, for both dependent variables, the mixed program, which included a definition and an example, was the most effective.

Another study (Guthrie, 1967) concerned the learning of rules for deciphering scrambled letter strings, or cryptograms. College students were taught to decipher cryptograms in four experimental conditions: (1) Example plus rule -- examples of cryptograms were presented for deciphering until subjects reached a criterion of eight consecutive correct responses; the deciphering rule (transpositional or

substitutional) was then taught until the subject could verbalize it. (2) Rule plus example -- the subject was first taught the rule and then deciphered examples to the same criterion. (3) Example -- only examples were presented until the criterion was reached. (4) Control -- the subjects learned Russian vocabulary. Feedback (the cryptogram with the correct word beside it) followed each trial for the three treatment conditions. The test consisted of 30 cryptograms. Ten were not used in training (remote transfer dependent variable); ten were formed from new words and rules not used in training but drawn from the same class of rules (near transfer dependent variable); ten were formed from new words but using the same rule used during training (retention dependent variable). Results indicated that (1) the Example group was superior to all other groups on the remote transfer task, (2) the Example and Example plus Rule groups were equal but significantly better than the other two groups for near transfer, and (3) the Rule plus Example group was superior to all other groups on the retention task. In addition, the Rule plus Example group learned faster than the other groups. Therefore, this study indicates that the superiority of single or combined methods depends on the nature of the learning criterion.

One other study (Anderson, 1973), the only published study found on teaching principles, also demonstrates the differential effectiveness of the treatment depending on the nature of the criterion task. In this study, high school students read a passage on classical conditioning in one of three experimental conditions. One group (the control) read three pages on classical conditioning. A second group read two pages on classical conditioning and one page on reinforcement and the principle that

intermittent reinforcement causes resistance to extinction along with an example illustrating the principle. A third group was identical to the second except that different words conveyed the concepts intermittent and resistance to extinction and a different example was used to illustrate the principle. The posttest included items that assessed the subjects' ability to apply the principle to instances that were either identical, similar, or dissimilar to the text example. The results showed that experimental subjects scored highest on identical items, slightly lower on similar items, and significantly lower on dissimilar items. Thus, performance on the criterion task was a direct function of type of example used during learning.

This group of studies on the use of both examples and definitions, then, yields a hodge podge of results: a definition mitigates the effect of number and type of examples, examples used in conjunction with definitions enhance learning, a definition presented with examples may inhibit learning, a definition plus examples is superior to either condition by itself, and the relative effectiveness of examples or examples with rules depends on the nature of the expected performance.

Research on the Use of Definitions Only

To confuse matters even more, one study (Anderson & Kulhavy, 1972) demonstrates that a high level of learning can result from definitions alone. In this study, college students received two study-test trials during which they saw one sentence definitions of 13 concepts. Half of the subjects were instructed to say aloud a sentence containing the defined word during the six second exposure of the definition; the other

half were told to read the definition aloud three times. After each study trial, subjects received two different test forms. Each form contained one multiple-choice item for each concept in which subjects were to choose the one alternative giving an instance of the concept. In the present context, the important result is that subjects were able to learn concepts from definitions alone, as long as they understood the definition.

In sum, the more classroom-oriented studies of concept learning do not answer the question of which instructional situations optimize learning. In fact, the composite findings engender more confusion than enlightenment. As Klausmeier et al. (1974) put it

> . . . research has not yet provided answers to such educationally important questions as: When introducing a new concept, how much of instruction should rely on verbally presented descriptions and definitions and how much on presentation of concrete exemplars? (p. 156)

Fortunately, however, there is hope for explaining the results at at least a general level within the context of cognitive psychology. Specifically, schema theory appears to offer a promising perspective on the process of learning concepts and principles. We turn now to an overview of schema theory.

Overview of Schema Theory

A theory of memory based on schema was proposed by Sir Frederic Bartlett in 1932 as an alternative to the "trace theory" of memory, which posited that memory is a conglomeration of separate immutable traces that represent exact copies of the original experience. According to the schema theory of memory, on the other hand, new experiences do not maintain their specific identity in memory but upon encoding are assimilated

into a general setting or framework (Bartlett, 1932) that represents the central tendency or communality of the class of perceived events (Attneave, 1957; Gomulicki, 1956). A schema, then, is a "cognitive template" (Rumelhart & Ortony, 1976, p. 51), a pattern or network of relationships that generally hold for the constituents of the concept. Schemata are

> . . . abstract and stereotyped descriptions of things and events. Schemata are abstract in the sense that they contain a slot or place holder for each constituent element in the knowledge structure. They are stereotyped in that they indicate the typical relationships among the elements. (Anderson, Pichert, Goetz, Schallert, Stevens, & Trollip, Note 1, pp. 18-19)

In other words, schemata are characterized by two features: (1) stereotyped, constant relationships among (2) abstract, variable components. The schema contains information about the constraints of the variable components -- the nature of the variables and the range of possible values each variable can assume. When the schema is activated in comprehension or memory, it is instantiated: the variables are "bound" by particular values; the "slots" or "placeholders" in the abstract structure are filled by specific instances.

With schemata, therefore, we can make sense of a situation whenever that situation can be interpreted as a particular instance of the appropriate generic concept in memory. Even if the incoming information is incomplete, the variable constraints and relationships within and between schemata allow us to make good guesses about unspecified variables, in other words, to assign "default values" (Kuipers, 1975) in order to complete the instantiation of a partially activated schema. For example, one can visualize an object as a cube even if only some of its planes and edges are in view. Presumably the schema for cube is activated from minimal

information about the interrelationship of faces, edges, and vertices, and the process of instantiation fills in the missing data. The same process seems to be a likely explanation for the experimentally verified phenomenon that in reading prose, general terms are typically encoded on the basis of a context-dependent instantiation. Anderson et al. (Note 1) claim, for instance, that in the sentence "The woman was outstanding in the theater," the words "outstanding" and "theater" activate interrelated schemata in such a way that "actress" becomes the most probable instantiated value for the general or variable term "woman."

The process of instantiation upon encoding has important implications for retrieval from memory (Rumelhart & Ortony, 1976). At encoding, the activated schemata assume certain values and patterns as a function of the particular context of the input. Retrieval of this original input depends on reactivation of its schematic structure by an additional input, or cue. But since each instantiation is context-dependent, a cue will be effective at retrieving the original schemata only to the extent that it triggers the same instantiation as did the original input. "Consequently changes in the contextual conditions prevailing at retrieval time compared with those at the time of presentation, may result in a failure to recognize the second presentation" (Rumelhart & Ortony, 1976, p. 29). Schema theory is in this regard quite consistent with the empirical and theoretical work of Tulving and Thomson (1973). Based on research showing failure to recognize recallable list words, Tulving and Thomson formulated the "encoding specificity hypothesis" which could well be a tenet of schema theory: "Specific encoding operations performed on what is perceived determine what is stored, and what is stored determines what retrieval

cues are effective in providing access to what is stored" (p. 369). Thus, according to both schema theory and the notion of encoding specificity, retrieval is highly dependent on the perceptual and cognitive conditions at the time of encoding.

Schema theory gives an elegant account of how knowledge is stored in human memory and what happens during comprehension and recall. In a tentative way, schema theory can also account for learning, where learning is viewed as the process of schema formation and modification. Still a neonate among learning theories, schema theory suggests the involvement of the following processes in learning (Rumelhart & Ortony, 1976). Schema specialization occurs when the variables of the schema become further constrained so that the range of possible values is narrowed. In this way, a schema becomes less abstract, i.e., more highly differentiated or specialized. Schema generalization occurs when a narrowly restricted or fixed portion of an existing schema is replaced by a variable to produce a new, more abstract or more generalized schema.

Having presented an overview of schema theory and its explanations of the storage of knowledge in memory, comprehension as a function of that stored knowledge, and learning as a process of schema change, we turn now to a discussion of how schema theory relates to the learning of concepts and principles.

Schema Theory Applied to Concept and Principle Learning

In the context of schema theory, the acquisition of a concept can be construed as the formation of the appropriate schema in memory. In schema terminology, we can say that a student has learned a concept when he has

stored in memory a data structure bearing the appropriate constant relationship among the attributes or dimensions of the concept as well as the range of possible values these dimensions can assume. "Adequate knowledge" of the concept implies that the corresponding schema is neither too specialized nor too generalized. The degree of specialization is such that the individual knows the limits of the range of acceptable variables; i.e., he can discriminate instances from noninstances. The degree of generalization is such that the variables are not overly constrained; i.e., the individual can generalize to new instances of the concept.

The learning of a new concept can proceed through either generalization or specialization. In the case of generalization, an individual encountering a concept for the first time is unable to assimilate it to an existing schema and will thus encode the information in its entirety as a sort of "schema" without variables, necessarily restricted to the values of the only instance perceived so far. As similar instances are encountered, differences between the encoded elements and the perceived elements cause the constants to be generalized to variables until the appropriate variable constraints have been established. In the case of specialization, the learner begins with a very general, abstract schema; successive encounters with instances of the concept establish constraints on the variables and cause the schema to become refined to the appropriate range of applicability.

When concept learning is viewed in terms of schema formation, the results of the concept learning studies can be more productively evaluated. Schema theory calls attention to the fact that two aspects of the studies

must be considered: the encoding processes and the retrieval processes. Both of these processes will be considered in turn.

Some studies showed that examples alone can be effective in producing concept learning. The explanation for this is that examples supply the evidence to structure the schema, including the generalization of an overly specialized schema or the specialization of an overly generalized schema. In the words of Rumelhart and Ortony (1976),

> . . . The role of examples in instruction can be regarded as providing individual cases in which a schema can have its variables bound; well-chosen examples will fully exploit such a schema by showing the nature and bounds of values that its variables can take. (pp. 51-52)

Schema theory can likewise explain the results of the studies that showed the superiority of learning from definitions and rules, for it is the very purpose of definitions and rules to convey the nature and limits of the concept variables and the relationships among them. In fact, provision of definitions or rules would seem to be a more efficient and effective way to communicate schemata, since the individual is spared the error-prone, inductive process of building up a schema "from scratch."

> . . .Providing information in a structured form most closely resembling the structure of the schema which will be required for its interpretation maximizes the likelihood that the interpretation will be appropriate and minimizes the processing required. (Rumelhart & Ortony, 1976, pp. 50-51)

Therefore, schema theory could be regarded as providing vindication for the conflicting research results: examples or definitions or both will work because they are all able to foster schema development. Unfortunately, the issue of an effective method for teaching concepts cannot be so readily resolved, for not just any old examples or definitions will do. In order to foster the development of the appropriate

schema using examples, the examples must be "well-chosen"; i.e., there must be exactly the right type, number, and sequence of examples to convey adequately the constant relationships among variables and the nature and limits of those variables. Presenting an incomplete set of examples can lead to undergeneralization, overgeneralization, or misconception. In the Anderson study (1973), for instance, the presentation of just one example appeared to produce undergeneralization, since subjects performed more poorly on items dissimilar to the presented item. In other words, the schema they encoded on the basis of one presented example was overly specialized.

On the other hand, in order to produce the appropriate schema using a definition, the definition must be " . . . in a structured form . . . closely resembling the structure of the schema" (Rumelhart & Ortony, 1976, pp. 50-51). This prescription presupposes knowledge of the actual schema structure as well as ability to render the structure into a comprehensible verbal format. A deficient definition can produce the same learning problems as an inadequate set of examples.

The requirements for effective examples and definitions are extremely stringent. It is unlikely that the conditions have been met by most of the researchers whose studies are cited earlier in this paper. The most successful method in each case is likely to be the one that, because of a lucky choice of examples or a fortuitous wording of the definition, comes closest to communicating an "adequate" schema. The studies are thus not a fair test of the relative effectiveness of examples and definitions in the encoding process of concept schema formation.

When we turn to a consideration of the retrieval process, the research results become even more equivocal. Relative effectiveness of methods is determined by performance on criterion tests. But according to schema theory, supported by the encoding specificity research, the effectiveness of a retrieval cue is a function of the ability of the cue to activate the schema formed on the occasion of the original input. Therefore, performance on a criterion test may not be a measure of the adequacy of schema formation at all, but merely of the similarity between the retrieval cue (test item) and the original input. In the absence of explicit information on the nature of the criterion task and its relation to the learning task in most of the reviewed studies, it is not certain what the dependent variables measure. Unless the criterion task can be shown to measure the content of the supposedly encoded concept schema, the measure obtained is not an index of concept learning.

In sum, applying schema theory to concept and principle learning has implications for both instruction and research: Concepts and principles must be analyzed in order to determine, as accurately as possible, the structure of the schema to be encoded, i.e., the constant relationships and the nature and bounds of the variables constituting the schema. Such an analysis will reveal the type and number of examples or the form of the definition needed to convey the schema during instruction. It will also yield a source of test items which are legitimate measures of the extent of schema formation. If such practices are followed, instruction should become more systematic and effective and research should produce some interpretable results.

Principle Analysis

The present study focused on principle analysis. The particular hypothesis guiding the study stemmed from the notion that

> . . . providing information in a structured form most closely resembling the structure of the schema which will be required for its interpretation maximizes the likelihood that the interpretation will be appropriate and minimizes the processing required. (Rumelhart & Ortony, 1976, pp. 50-51)

It was thought that performing a principle analysis would reveal "the structure of the schema" to the extent that a definition of the domain of the principle could be generated. The specific hypothesis that emerged was that presentation of such a definition or statement of the domain of applicability of a principle, derived from an analysis of the principle, would produce greater transfer (ability to apply the principle to instances not previously encountered) than either presentation of an example of the principle alone or an example in conjunction with a statement of the principle or a statement of the principle alone. A related hypothesis was that treatment would interact with transfer task. Specifically, it was hypothesized that transfer with the "example" conditions would be greater for instances similar to the presented example than for instances dissimilar to the presented example.

Before the study could be launched, it was necessary to establish a methodology for performing a principle analysis. No real precedents for principle analysis had been set. The closest approximation was found in Anderson's (1973) study of principle learning. In this study Anderson attempted "to accurately capture the full sense of the principle" (p. 28) by generating an elaborated statement of the principle with letters substituted for each possible variable. Although Anderson did not relate

principle analysis to schema theory, his analyses seemed to capture the supposed structure of a schema -- "an abstract and sterotyped description" (Anderson et al., Note 1, p. 18) entailing constant relationships among variable components. Therefore, a similar approach to principle analysis was pursued in the present study.

Four psychological principles were selected for analysis. The principles were first written in common English in a way that would capture the constant relationships of the principle. The following is an example of the common English statement of one of the selected principles (transfer of learning):

> Simplified somewhat, the first two of Osgood's "Laws of Transfer" are:
>
> (1) If a second learning task consists of a different stimulus but the same response as the first learning task, the second task will be <u>easier</u> to learn than the first (positive transfer).
>
> (2) If a second learning task consists of the same stimulus but a different response than the first learning task, the second task will be <u>harder</u> to learn than the first (negative transfer).

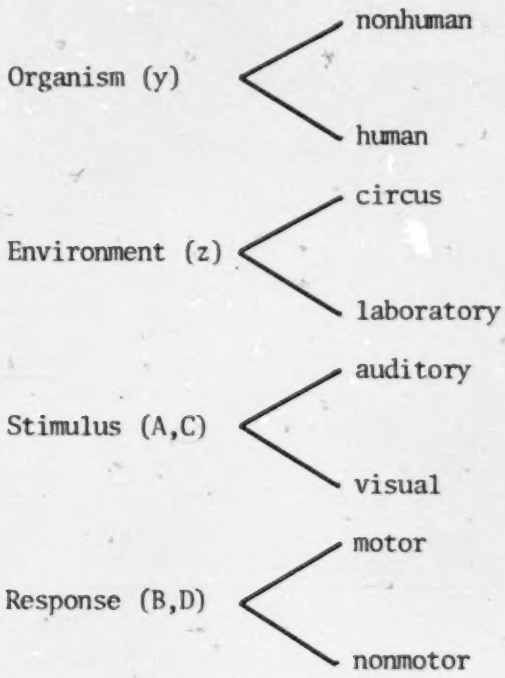
Next, all variables in the principle statement were assigned letters. The transfer of learning principle became:

> An organism <u>y</u> in environment <u>z</u> learns a first task in which a stimulus (A) is followed by a response (B).
>
> (1) If a second task consists of a different stimulus (C) but requires the same response (B), then <u>y</u> (in <u>z</u>)

will find the second task easier to learn than the first task.

(2) If the second task consists of the same stimulus (A) but requires a different response (D), then y (in z) will find the second task harder to learn than the first task.

Then a "replacement set" was constructed for each variable. The replacement set was designed to convey the bounds of the variables, or the range of values that the "slots" in the schema could assume. Since the nature of the experiment required only two replacement sets for each variable, the bounds were often artificially constrained, a situation which need not occur under normal conditions. The replacement sets for the transfer of learning principle are shown below:



The "domain statement" for the principle was then constructed. Prefaced by "It is believed that this principle applies to . . . " the

domain statement went on to suggest that all variables could be replaced by both members of the corresponding replacement set. The following is the domain statement for the transfer of learning principles:

> It is believed that these principles apply, among other things, to animals in circuses and people in experiments. The stimulus could be almost anything that can be either seen or heard, and the response could be any physical movement or verbal reply.

The replacement sets were also used to create examples of the principle. One member of each replacement set was chosen, and a concrete exemplar of that general term was selected. The concrete exemplars were then substituted for the corresponding variables in the original principle statement. For the purposes of this study, a second example was created from the other members of the replacement set. In this way the two examples for each principle were related to the principle along the same dimensions, but they differed in the values of those dimensions. Here is one example so created:

> For example, a seven-year-old boy in a laboratory experiment has learned to say "George Washington" after he is shown the word "President." The boy will find it <u>easier</u> to learn a second task in which he must say "George Washington" after he is shown the word "General." The boy will find it <u>harder</u> to learn a second task in which he must say "Thomas Jefferson" after he is shown the word "President."

In a similar manner, the replacement sets were used to construct the multiple-choice criterion items testing transfer. Different exemplars of the members of the replacement set than those used in the instructional

example were selected. The antecedent of the principle, with the specific instances substituted for the corresponding variables, was presented as the stem of the item. The correct consequent, again with the specific instances substituted for the corresponding variables, appeared as an alternative along with several other plausible distractors. Within the context of this study it was thus possible to generate test items that were similar to the instructional example (i.e., instances of the same members of the replacement set) or dissimilar to the instructional example (i.e., instances of the opposite members of the replacement sets). The following are "similar" and "dissimilar" test items for the example presented above.

Similar: In a laboratory a housewife has been trained to shout "Great!" when she sees a "Brand X" detergent passing by on a conveyor belt. According to the principles of transfer of learning, she will have a simpler time mastering a second requirement in which she must

1. shout "Clean" when she sees Brand X.
2. shout "Great!" when she sees Brand A.
3. shout "Clean!" when she sees Brand A.
4. shout "Clothes!" when she sees Brand Z.
5. shout "Wash!" when she sees Brand Y.

Dissimilar: A zebra has been trained to stand on his rear legs when the circusmaster claps his hands. According to the principles of transfer of learning, the zebra will find it more difficult to learn a new trick in which he must

1. stand on his rear legs when the circusmaster rings a bell.
2. give a bow when the circusmaster says "Go!"
3. balance on a stool when the circusmaster rings a bell.
4. balance on a stool when the circusmaster claps his hands.
5. lift one foreleg when the audience applauds.

To summarize, principle analyses were conducted in order to yield: (1) a statement of the domain of applicability of the principle that hopefully approximated the structure of the schema to be encoded, (2) examples of the principle that spanned the domain of applicability, and (3) systematically produced test items that bore an operationally defined relationship to the instructional input.

The above procedure laid the groundwork for an investigation of the two major hypotheses. To repeat, these hypotheses were

(1) Transfer would be greater with a statement of the domain of applicability of the principle than with a presentation of an example alone, the principle alone, or the principle plus an example, and

(2) Transfer would be greater for instances similar to the presented example than for instances dissimilar to the presented example.

A final, subsidiary interest in the study was to further test the question of whether a pretest has a "priming" effect on learning from prose. As Anderson and Biddle (1975) found in their comprehensive review of adjunct questioning studies, questions asked before passages containing

the answers have a significant facilitative effect on performance on repeated criterion test items but an inhibiting effect on performance on new criterion test items. This study was designed to test the hypothesis that a pretest will facilitate performance on repeated posttest items.

METHOD

Subjects

Three hundred ninety-five juniors and seniors from a middle to upper-middle class public high school in suburban Chicago participated in the study.

Design

The design was a 2 x 3 x 4 x 6 factorial design. The three between-subjects factors were type of pretest (two levels), type of principle (four levels), and treatment condition (six levels); the within-subjects factor was type of item on the criterion test (three levels). For the pretest factor, subjects received either a 12-item multiple choice pretest identical to the criterion test or the Surface Development Test (Educational Testing Service, 1962) which required them to visualize how pieces of paper can be folded to form three-dimensional objects. For the factor involving type of principle, subjects received a passage concerning either cognitive dissonance theory, reinforcement, transfer of learning, or reaction time experiments. Subjects received one of six levels of treatment: (1) Principle only. Subjects received a description of a principle related to the passage they read. (2) Principle plus Domain Statement. Subjects received a description of a principle related to the passage they read as well as a statement of the "domain of applicability" of the principle, as described previously. (3) Principle plus Example 1 and (4) Principle plus Example 2. Subjects received a description of a principle related to the passage they read and one of two examples illustrating the principle. (5) Example 1 Only and (6) Example 2 Only. Subjects received

one of two examples illustrating a principle related to the passage they read but not a statement of the principle itself. All subjects received the three levels of posttest questions -- six "general" items testing retention of the relevant passage content and two sets of three items each assessing comprehension of the relevant principle, one set similar to Example 1 (and dissimilar to Example 2) and one set similar to Example 2 (and dissimilar to Example 1). In addition, the 54 item version of the Wide Range Vocabulary Test (French, Ekstrom & Price, 1963) was administered to all subjects in order to obtain a measure of verbal ability to be used as a covariate.

Materials

Four passages were written to provide the background information and conceptual base deemed necessary for an understanding of the four psychological principles. The passages ranged in length from about 275 words (cognitive dissonance theory) to about 550 words (reinforcement). Descriptions/explanations of the related principles were then prepared for each of the passages. These descriptions/explanations ranged in length from about 70 words (transfer of learning) to about 275 words (cognitive dissonance theory). The passage and description/explanation for the principle of transfer of learning is found in the Appendix.

A "domain statement," two instructional examples, and six test items were constructed for each principle in the manner previously described. Three of the items were similar to Example 1 but dissimilar to Example 2; the other three items were similar to Example 2 but dissimilar to Example 1. Six additional multiple-choice achievement test items were constructed

for each passage. These items were considered filler items because they related to the passage proper rather than to the principle itself, which is the concern of this study. These six items were derived from close-to-verbatim text sentences and required the student to select the deleted element. Since such items can presumably be answered on the basis of orthographic or phonologic encoding, they cannot be considered to be measures of "comprehension" (Anderson, 1972).

Five alternatives were provided for each of the 12 multiple-choice items: the correct response alternative and four plausible distractors. For the subjects receiving a pretest identical to the criterion test, the items appeared in different random orders for the two test administrations. In order to facilitate machine scoring, items across the four passages were matched in the sense that (1) for each item number correct responses were in the same position across the four forms, (2) items similar to Example 1 were in the same position within the test, and (3) items similar to Example 2 were in the same position within the test.

One constructed response item was also included in the test. For all passages, this item asked subjects to explain the relevant principle.

Experimental booklets were assembled in the following order: pretest directions, pretest, passage-reading directions, passage, vocabulary test directions, vocabulary test, posttest directions, posttest. The vocabulary test was placed between the passage and the posttest in order to minimize recall from short-term, nonsemantic memory.

Procedure

Over two days, the experiment was run in the subjects' classrooms by three experimenters using standard instructions. The subjects were

assigned to conditions by distributing randomly ordered stacks of the booklets containing the experimental material. Set amounts of time were allowed for each of the four sections of the task; these times appeared to be adequate for subjects to complete the task.

The pretest, vocabulary test, and posttest multiple choice items were machine scored. For the posttest items, separate scores were obtained for the six general items and the two sets of three transfer items each. Comparable scales were obtained by dividing the "general" total by six and the "transfer" totals by three. The open-ended responses were not scored for this study.

RESULTS

A preliminary analysis was done to determine if an analysis of covariance using verbal ability as a covariate would be useful. First, a three way analysis of variance with the factors of pretest, principle, and treatment was conducted using score on the Wide Range Vocabulary Test as the dependent variable. The analysis revealed no significant differences between groups on any factor. Second, in an analysis of variance with posttest score as the dependent variable, the reduced error term that would result from eliminating the effect of verbal ability was computed. The formula used was

$$\sigma_e^2(1 - \rho_w^2)(1 + \frac{1}{df_e - 2})$$

using the unadjusted mean square (.185) as an estimate of σ_e^2 and the squared correlation between verbal ability scores and dependent variable ($\underline{r}$ = +.40904; $\underline{r}^2$ = +.16731) as an estimate of ρ_w^2. The adjusted mean square thus computed is .15455, which still fails to yield a significant $\underline{F}$ ratio for the treatment effect. Thus, it was decided to proceed with an analysis of variance rather than an analysis of covariance.

An analysis of variance with the factors of pretest, principle, treatment, and item set was conducted using posttest score as the dependent variable. The results are reported in Table 1. All results subsequently reported as significant are significant at $\underline{p} < .01$. The one nonsignificant main effect was treatment condition. Thus, the hypothesis that subjects receiving the principle plus a domain statement of the principle would score higher than subjects receiving a principle

Table 1

Analysis of Variance Summary Table
Posttest Score

Source	df	SS	MS	F
Between				
Pretest	1	1.76	1.76	9.50*
Principle	3	2.38	0.79	4.29*
Treatment	5	0.57	0.11	0.61
Pretest x Principle	3	1.25	0.42	0.24
Pretest x Treatment	5	0.77	0.15	0.83
Principle x Treatment	15	2.16	0.14	0.78
Pretest x Principle x Treatment	15	2.66	0.18	0.96
Error	347	64.22	0.19	
Within				
Item Set	2	4.55	2.27	42.12**
Pretest x Item Set	2	0.21	0.10	1.97
Principle x Item Set	6	4.93	0.82	15.23**
Treatment x Item Set	10	2.97	0.30	5.51**
Pretest x Principle x Item Set	6	0.41	0.07	1.25
Pretest x Treatment x Item Set	10	0.52	0.05	0.95
Principle x Treatment x Item Set	30	1.43	0.05	0.88
Pretest x Principle x Treatment x Item Set	30	0.98	0.03	0.60
Error	694	37.45	0.05	

*$p < .01$

**$p < .00001$

only, an example only, or a principle plus an example was not confirmed. The hypothesis that subjects receiving a pretest identical to the post-test would outperform subjects receiving an irrelevant pretest was confirmed. A second significant main effect was that of Item Set. The means are reported in Table 2. A Tukey's HSD test showed a significant difference between scores on general items and scores on both similar and dissimilar items that barely missed significance at the .05 level.

Table 2

Mean Proportion Correct as a Function of Item Set

Type of Item	Mean Proportion
General	.58
Dissimilar	.44
Similar	.48

The hypothesis that treatment would interact with item set was also confirmed. The means for the four treatments that included examples are presented in Table 3 and the interactions are plotted in Figure 1. A planned comparison confirmed the prediction about the effect of examples on transfer. Subjects performed significantly better [$t(694) = 2.5$] on transfer instances that were similar to the example they had seen than on items that were dissimilar to the example they had seen. For whatever it is worth, subjects also scored significantly higher on the general retention items than they did on either the similar [$t(694) = 4.5$] or the dissimilar [$t(694) = 6.9$].

Table 3

Mean Proportion Correct

Treatment x Item Set Interaction
for Treatments Including Examples

Treatment	General	Dissimilar	Similar
Principle + Example 1	0.60	0.42	0.58
Principle + Example 2	0.62	0.49	0.47
Example 1 Only	0.58	0.35	0.56
Example 2 Only	0.58	0.54	0.39

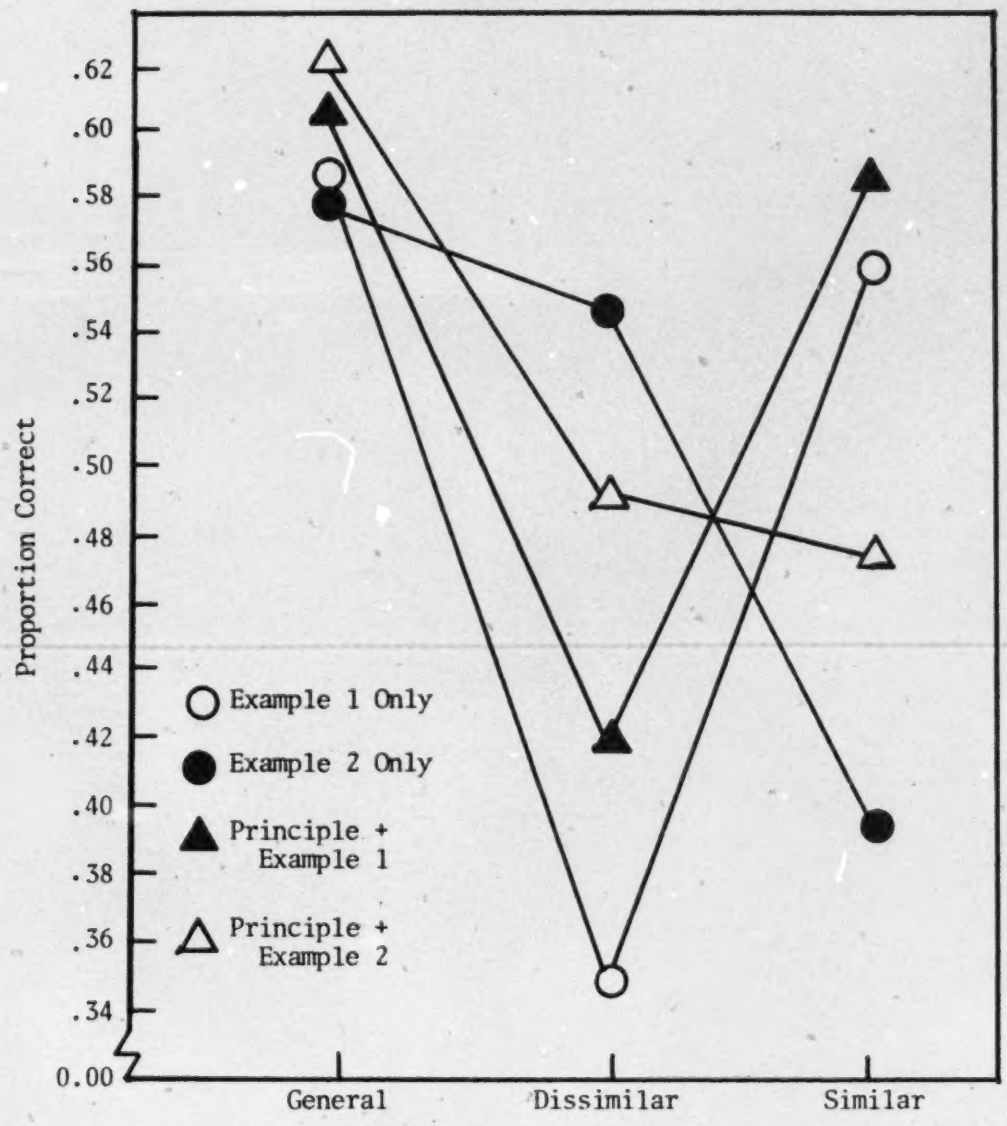


Figure 1. Treatment x Item Set interaction

A peculiar result appearing in Table 3 and Figure 1 is that the relative position of means on similar and dissimilar items for treatment conditions including Example 1 is quite different from the situation found with treatment conditions including Example 2. In other words, in Example 1 treatments the dissimilar transfer item means were substantially below the similar transfer item means whereas in Example 2 treatments the dissimilar item means are at least somewhat greater than the similar item means. A possible explanation was that the two item sets differed in difficulty level. An analysis of variance with the two "absolute" item sets (no longer defined relative to the example presented) as dependent variable confirmed this suspicion.

The original analysis of variance also revealed a significant main effect for Principle. The mean proportion correct for the four principles are reported in Table 4.

Table 4

Mean Proportion Correct

as a Function of Type of Principle

Principle	Mean Proportion
(1) Reinforcement	0.47
(2) Cognitive Dissonance	0.46
(3) Transfer of Learning	0.51
(4) Reaction Time	0.58

A Tukey HSD test for all pairwise comparisons among means failed to reveal any significant differences. Although unusual, this situation can occur because the over-all F ratio is equivalent to a simultaneous test of the hypothesis that all possible comparisons among means are equal to zero. Therefore, for this set of data, the significant comparison could involve some undetermined linear combination of means (Kirk, 1968).

The Principle x Item Set interaction was also significant. From the means in Table 5 and the plotted interactions in Figure 2 it can be seen that Principle 4 behaved in an aberrant fashion. A Scheffé test verified that Principle 4 means were significantly higher than the average of the other three principle means on general, dissimilar, and similar items.

Table 5

Mean Proportion Correct

Principle x Item Set Interaction

Principle	General	Dissimilar	Similar
1	0.57	0.41	0.43
2	0.64	0.34	0.41
3	0.64	0.42	0.45
4	0.51	0.60	0.62

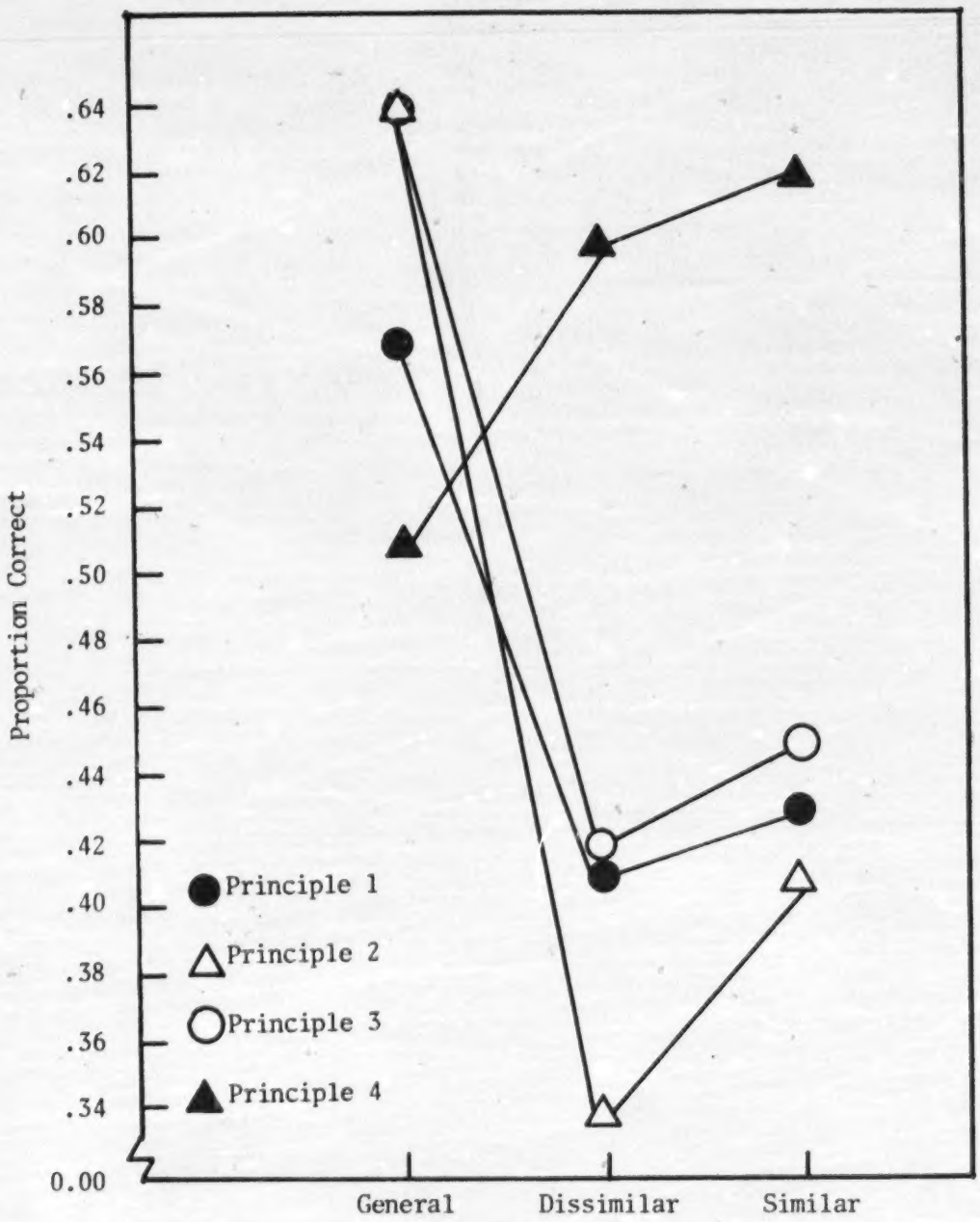


Figure 2. Principle x Item Set interaction

DISCUSSION

Although the results failed to confirm the pedagogical hypothesis that presentation of a principle in conjunction with a domain statement would produce superior learning to presentation of a principle or example alone or a principle in conjunction with an example, there were several potentially important aspects to the study.

First, the study utilized the crude beginning of a methodology that could prove useful to both educators and researchers -- principle analysis. By analyzing the constant relationships and variables of principles and delineating the range of values those variables can assume, it is possible to systematically generate the full range of examples and comprehensive definitions that are needed for adequate schema development. Since the domain of possible examples is defined by such an analysis, it is also possible to construct domain-referenced achievement tests, which are valid and sensitive indices of comprehension and transfer. Analysis of principles is important to the instructor because he knows what to teach and how to assess whether his teaching has been effective. Analysis of principles is important to the researcher because he can operationally define his independent variable of instruction and his dependent variable of criterion test so that his results are interpretable and comparable to the results of others using the same analytic procedure.

Second, the study replicated and extended the result of the Anderson (1973) study: When instruction includes a single example, subjects perform better on test items that are similar to the presented example than they do on test items that are dissimilar to the presented

example. This result is quite consistent with schema theory. When a single example is presented, the schema will tend to be overspecialized so that only a very narrow range of cues will serve to reactivate it. A retrieval cue similar to the original input will be interpreted in the same way and will reinstate the original schema, but a dissimilar retrieval cue will be interpreted in a novel way and will thus fail to reinstate the original schema.

Finally, the study confirmed once more the finding that a pretest has a "priming" effect on learning from prose when the pretest consists of items that will be repeated on the criterion test. Presumably the questions direct the reader's attention to those facts that are apparently important for him to know within the context of the particular task. One who is exposed to a pretest probably also becomes "test wise"; he knows the precise nature of the task he is likely to have to repeat at some point in time.

REFERENCE NOTES

1. Anderson, R. C., Pichert, J. W., Goetz, E. T., Schallert, D. L., Steven, K. V., & Trollip, S. R. Instantiation of general terms (Tech. Rep. 10). Urbana, Ill.: University of Illinois, Laboratory for Cognitive Studies in Education, March 1976.

2. Markle, S. M., & Tiemann, P. W. Some principles of instructional design at higher cognitive levels. Paper presented at the International Congress for Instructional Technology, Berlin, Germany, April 1972.

LIST OF REFERENCES

Anderson, R. C. How to construct achievement tests to assess comprehension. Review of Educational Research, 1972, 42, 145-170.

Anderson, R. C. Learning principles from text. Journal of Educational Psychology, 1973, 64, 26-30.

Anderson, R. C. The notion of schemata and the educational enterprise. In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), Schooling and the acquisition of knowledge. Hillsdale, N. J.: Lawrence Erlbaum Associates, in press.

Anderson, R. C., & Biddle, W. B. On asking people questions about what they are reading. In G. Bower (Ed.), Psychology of learning and motivation, Vol. 9. New York: Academic Press, 1975.

Anderson, R. C., & Faust, G. W. Educational psychology: The science of instruction and learning. New York: Dodd, Mead, 1973.

Anderson, R. C., & Kulhavy, R. W. Learning concepts from definitions. American Educational Research Journal, 1972, 9, 385-390.

Attneave, F. Transfer of experience with a class-schema to identification-learning of patterns and shapes. Journal of Experimental Psychology, 1957, 54, 81-88.

Bartlett, F. C. Remembering. Cambridge, England: Cambridge University Press, 1932.

Battig, W. F., & Bourne, L. E., Jr. Concept identification as a function on intra- and interdimensional variability. Journal of Experimental Psychology, 1961, 61, 329-333.

Carroll, J. B. Words, meanings, and concepts. Harvard Educational Review, 1964, 34, 178-202.

Clark, D. C. Teaching concepts in the classroom: A set of teaching prescriptions derived from experimental research. Journal of Educational Psychology, 1971, 62, 253-278.

French, J. W., Ekstrom, R. B., & Price, L. A. Kit of reference tests for cognitive factors. Princeton, N. J.: Educational Testing Service, 1963.

Gagne, R. M. The conditions of learning. New York: Holt, Rinehart, & Winston, 1965.

Gomulicki, B. R. Recall as an abstractive process. Acta Psychologica, 1956, 12, 77-94.

Guthrie, J. T. Expository instruction versus a discovery method. Journal of Educational Psychology, 1967, 58, 45-49.

Hively, W. Domain-referenced testing: Basic ideas. Educational Technology, 1974, 14, 5-10.

Johnson, D. M., & Stratton, R. P. Evaluation of five methods of teaching concepts. Journal of Educational Psychology, 1966, 57, 48-53.

Kirk, R. E. Experimental design: Procedures for the behavioral sciences. Belmont, Ca.: Brooks/Cole, 1968.

Klausmeier, H. J., Ghatala, E. S., & Frayer, D. A. Conceptual learning and development: A cognitive view. New York: Academic Press, 1974.

Kuipers, B. J. A frame for frames: Representing knowledge for recognition. In D. G. Bobrow & A. M. Collins (Eds.), Representation and understanding: Studies in cognitive science. New York: Academic Press, 1975.

Markle, S. M. They teach concepts, don't they? Educational Researcher, 1975, 4, 3-9.

Merrill, M. D., & Tennyson, R. D. The effects of types of positive and negative examples on learning concepts in the classroom. Washington, D. C.: U. S. Department of Health, Education, and Welfare, Office of Education, Bureau of Research, September 1971. (ERIC Document Reproduction Service No. ED 055 068)

Roderick, M. C. The effects of several ways of writing paragraphs on the learning of principles. Unpublished doctoral dissertation, University of Illinois, 1969.

Rumelhart, D. E., & Ortony, A. The representation of knowledge in memory. In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), Schooling and the acquisition of knowledge. Hillsdale, N. J.: Lawrence Erlbaum Associates, in press.

Surface Development Test, Princeton, N. J.: Educational Testing Service, 1962.

Tulving, E., & Thomson, D. M. Encoding specificity and retrieval processes in episodic memory. Psychological Review, 1973, 80, 352-373.

APPENDIX

PASSAGE AND DESCRIPTION FOR TRANSFER OF LEARNING PRINCIPLE

P-1

Transfer of Learning

An important problem in education is the extent to which the learning of one thing affects the learning of something else. The influence that one task may have on the subsequent learning of another is called transfer of learning. Transfer of learning may take three different forms: 1) learning one task may aid or increase learning on a second task, which represents positive transfer, 2) learning one task may detract from learning on a second task, which represents negative transfer, or 3) learning one task may have no effect on another task, which is known as zero transfer.

Early educators believed that transfer was a very general phenomenon. They assumed that individuals had faculties (such as reasoning, memory, or perception), that, like a muscle, could be developed by exercise. Reasoning from this formal discipline approach, therefore, educators advocated memorizing poetry to strengthen the memory and studying geometry to discipline the mind.

In contrast to the formal discipline approach, the famous psychologist E. L. Thorndike proposed that transfer was much more restricted. Thorndike claimed that training transfers only as long as certain features of the two tasks, such as aims, methods, and approaches, are identical. Published in 1914, this "theory of identical elements" proposed that "a

change in one function alters any other only in so far as the two functions have as factors identical elements." These elements, though not precisely defined, apparently could be fairly general. Thorndike felt, for example, that training in addition helps with multiplication (both operations share the identical element of addition).

Experimental psychologists following Thorndike focused on two "elements" -- the external situation or event (the stimulus) and the organism's reaction or response to the stimulus. Therefore, in comparing a previously learned task with a new one in order to determine what the transfer effects would be, these experimenters analyzed changes in both stimulus and response.

In 1949, C. E. Osgood reviewed the existing literature on transfer and formulated generalizations which he claimed could accurately describe all of the experimental results. These principles became knows as "Osgood's Laws of Transfer." Although subsequent studies have shown that Osgood's generalizations do not apply in all cases, these principles nevertheless represent a landmark in the work on transfer of learning.

P-2

Simplified somewhat, the first two of Osgood's "Laws of Transfer" are:

1) If a second learning task consists of a different stimulus but the same response as the first learning task, the second task will be easier to learn than the first (positive transfer).
2) If a second learning task consists of the same stimulus but a different response than the first learning task, the second task will be harder to learn than the first (negative transfer).